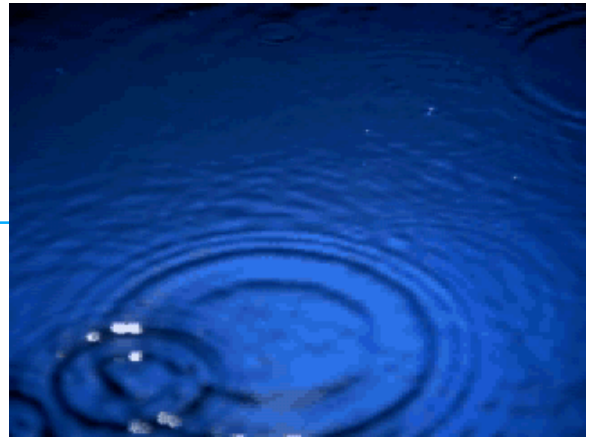
GPM

GLOBAL PRECIPITATION MEASUREMENT

GPM
Global Precipitation Measurement

US GV Strategy and Plans



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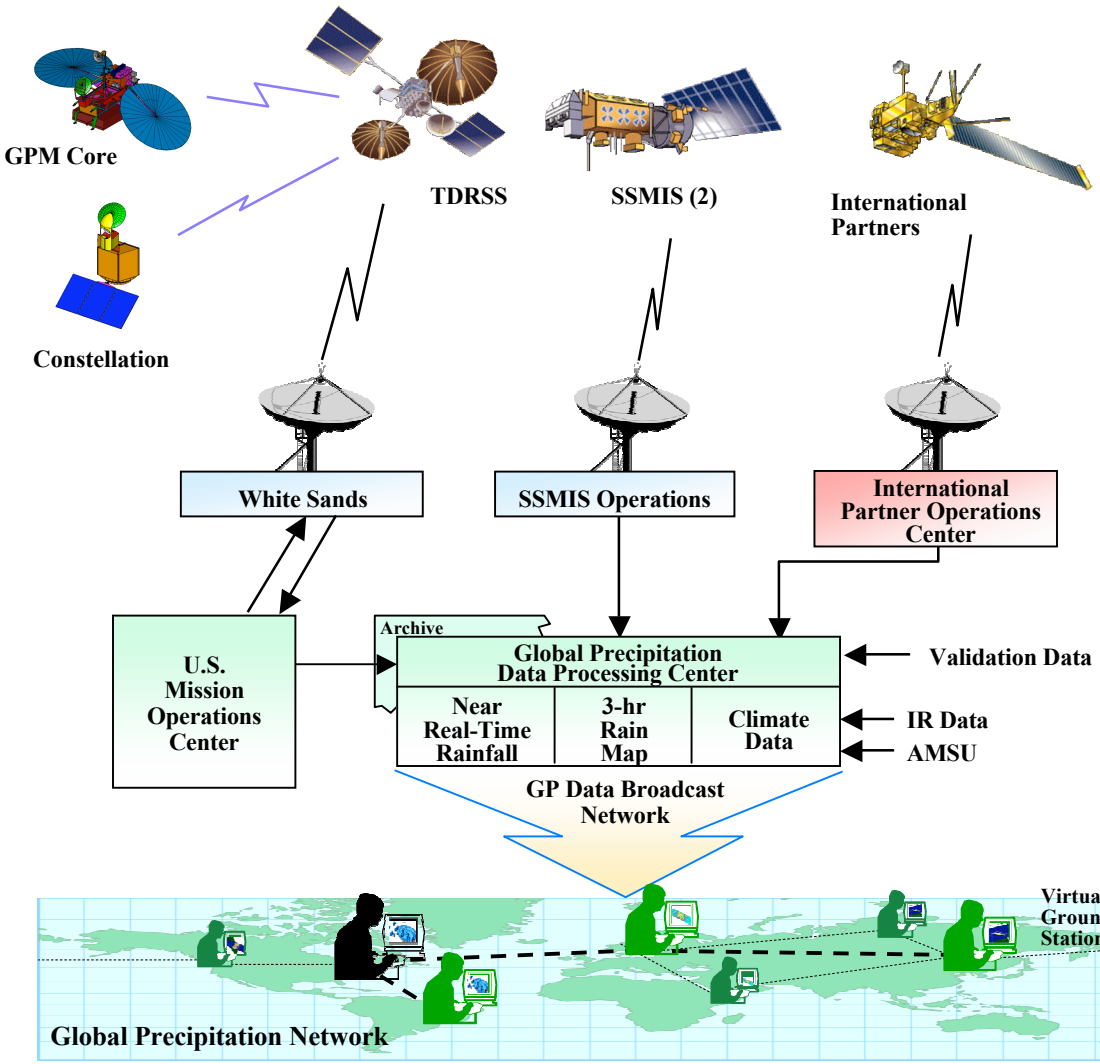
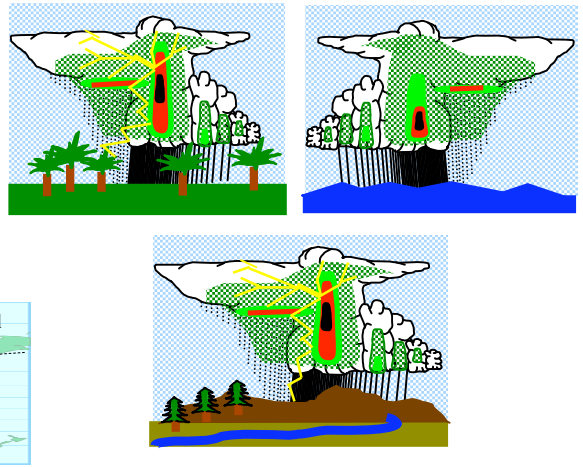
2nd International GPM Ground Validation Workshop 27-29 September 2005, Taipei, Taiwan

Key Components of GPM



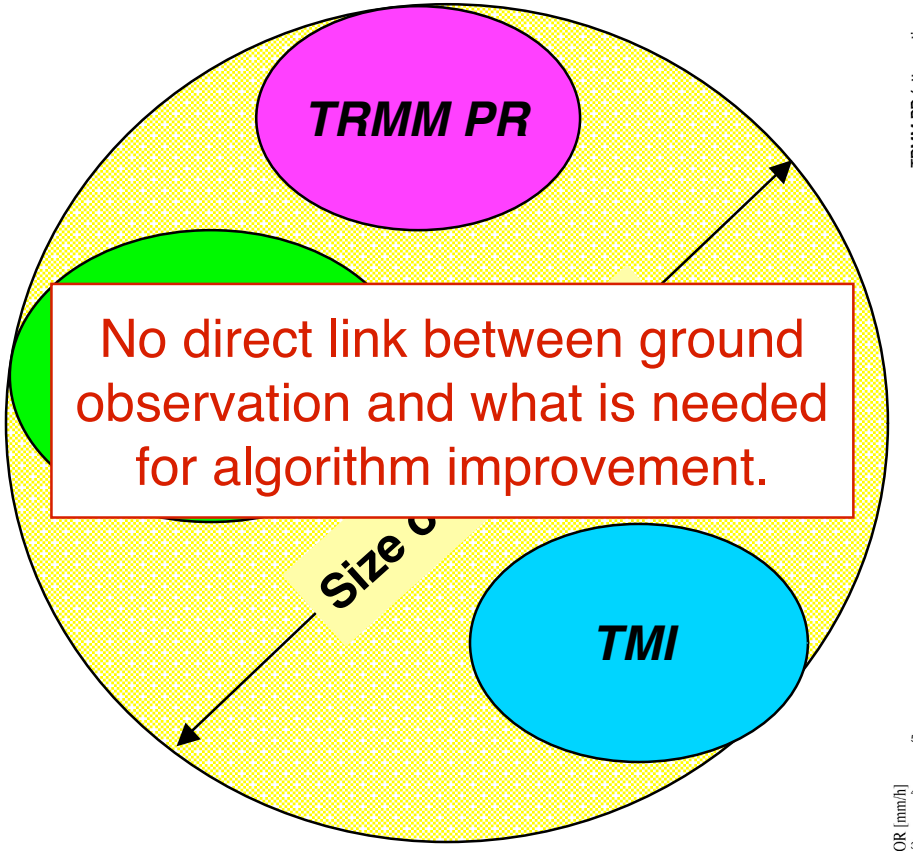
- Space segment
  - Core satellite
  - Constellation satellites
- Ground segments
  - Validation sites
  - Data system

Ground Validation Sites

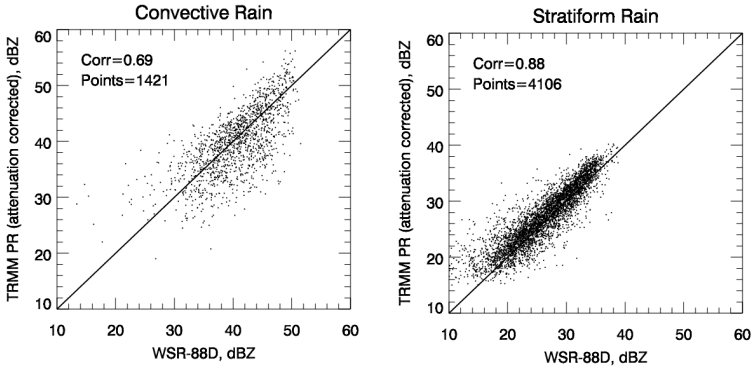


Direct validation of surface precipitation – TRMM

Bias ~ 10%



No direct link between ground observation and what is needed for algorithm improvement.



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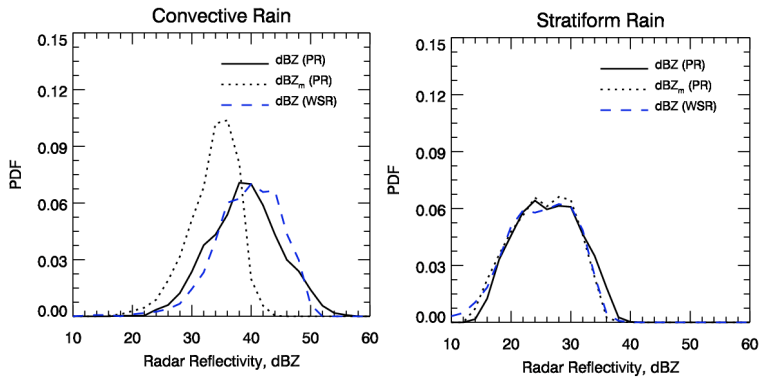
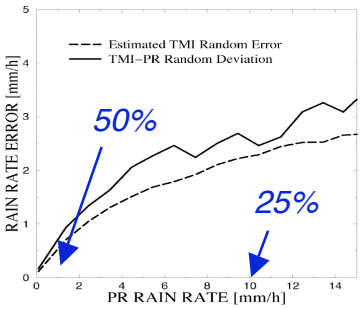


Meneghini et al.



Olson et al.

Random Errors ~ 25-50%
(between 1-10 mm/h)

GPM Science Objectives

GPM is a science mission with integrated applications goals

- *Improved global precipitation measurement capability from space*
  - ***by using the GPM Core as a calibrator of dedicated and operational PMW sensors***
- *Improved understanding of the water/energy cycle variability and fresh water availability*
  - ***through better measurements of the space-time variability of global precipitation and closure of the water/energy budget***
- *Improved weather prediction skills*
  - ***through more accurate and frequent measurement of instantaneous rain rates with better error characterizations and improved assimilation methods***
- *Improved flood-hazard and fresh-water-resource prediction capabilities*
  - ***through better temporal sampling and spatial coverage of high-resolution precipitation measurements and an integrated strategy to hydrometeorological measurement & modeling***
- *Improved climate prediction*
  - ***through better understanding of precipitation microphysics, surface water fluxes, soil moisture storage, and latent heating in the Earth's response to climate changes***

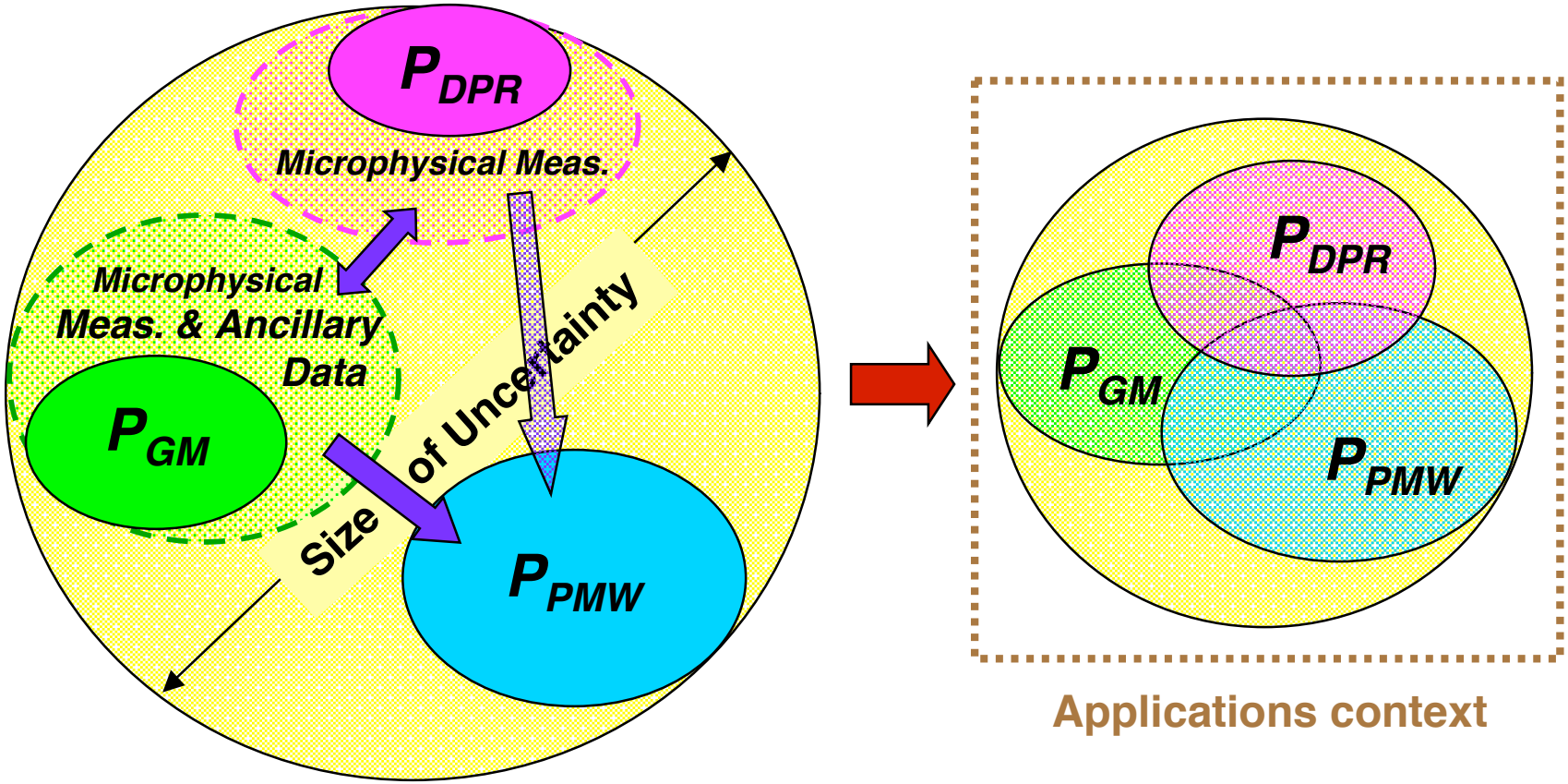
GPM Validation Objectives

GPM validation goes beyond direct comparisons of surface precipitation rates between ground and satellite measurements

GPM Ground Validation Objectives:

- ***Using ground-based measurements (including field campaigns) to advance understanding of precipitation physics for satellite algorithm and data product improvements***
- ***Providing ancillary measurements to improve GPM data applications in numerical weather prediction & climate modeling***
- ***Providing testbeds for improving GPM data usage in hydrometeorological modeling and prediction.***

GPM Validation Concept



GV goal is to provide ground observations for direct satellite product assessment and for algorithm/application improvements

US GPM Ground Measurement Advisory Panel (Chair: Chris Kummerow) recommends:

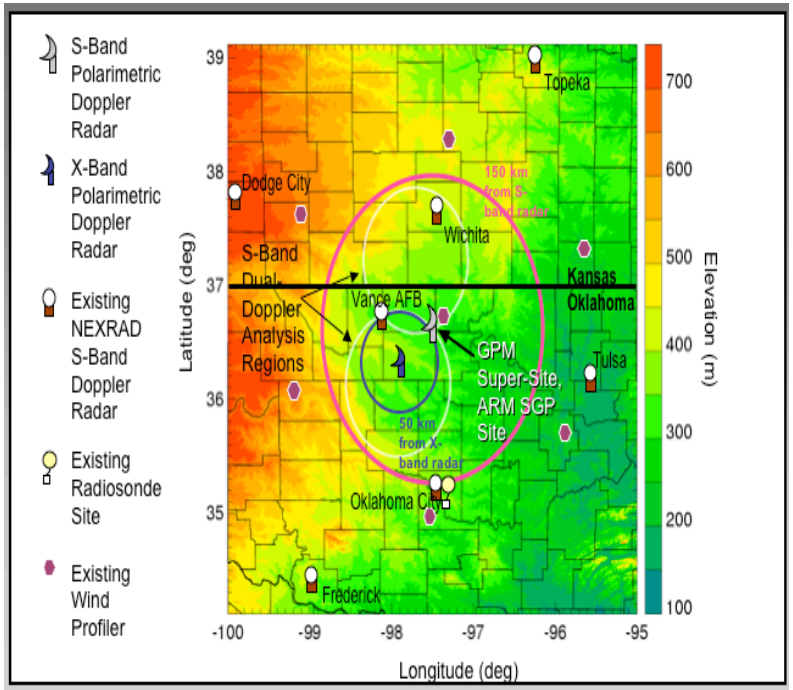
- ***Surface precipitation statistical validation sites for direct assessment of GPM satellite data products:***
  - *Co-located with existing or upgraded national network (NEXRAD etc.) and dense gauge networks*
- ***Precipitation process sites for improving understanding of precipitation physics, modeling, and satellite retrieval algorithms:***
  - *Continental tropical, mid- and high-latitude sites (including orographic/coastal sites and targeted sites for resolving discrepancies between satellite algorithms)*
  - *Oceanic tropical and mid-latitude sites*
- ***Integrated hydrological sites for improving hydrological applications:***
  - *Co-located with existing watersheds maintained by other US agencies and international research programs*

These sites can also be designed to overlap.

Precipitation Process Sites

Providing measurement of precipitation processes and ancillary observations for improving the understanding and modeling of precipitation in both physical and radiance spaces

- Reference Standard Sites for identifying and correcting fundamental problems in DPR and PMW retrieval algorithms over land and oceans. These sites also provide ancillary observations for evaluating and improving precipitation parameterizations and satellite radiance simulations.
- Orographic Sites for identifying and correcting problems in algorithms over complex terrains.
- Coastal Sites for correcting algorithm problems associated with coastal regions.
- Additional Sites as needed for resolving discrepancies between satellite algorithms at specific locations.
- Possible instrumentation:
  - surface meteorological stations and rawinsondes
  - scanning polarimetric radars operating at S and X band
  - vertically pointing profiling radars, disdrometers
  - rain gauge networks
  - aircrafts with multi-frequency radar & radiometer for explicit ice measurements



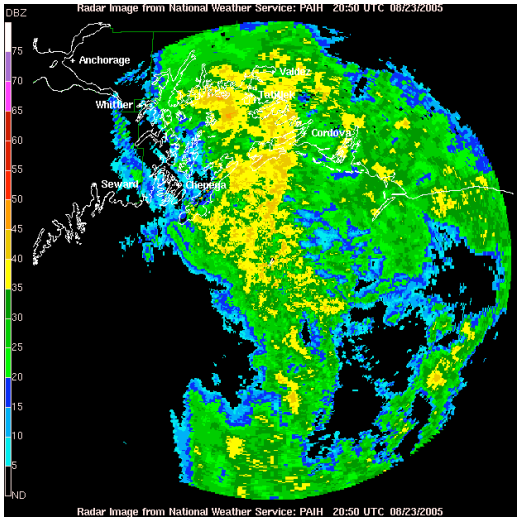
Example of a possible Reference Standard Site at DOE-ARM CART

A key element over land may be core "mobile" radars that can be re-deployed to different locations for extended but limited durations.

Precipitation Process Sites (Cont'd)

Possible ocean sites:

- High-Latitude Ocean Site: Middleton Island, Alaska
- Tropical Sites: Japanese Okinawa Site, Kwajwelein Site
- Aircraft Campaigns



Low-level radar reflectivity observed by PAIH WSR-88D radar on Middleton Island. Well-positioned relative to the typical storm track of Pacific low pressure systems.

Orographic sites:

- Resolving discrepancies between ground measurements, and satellite measurements

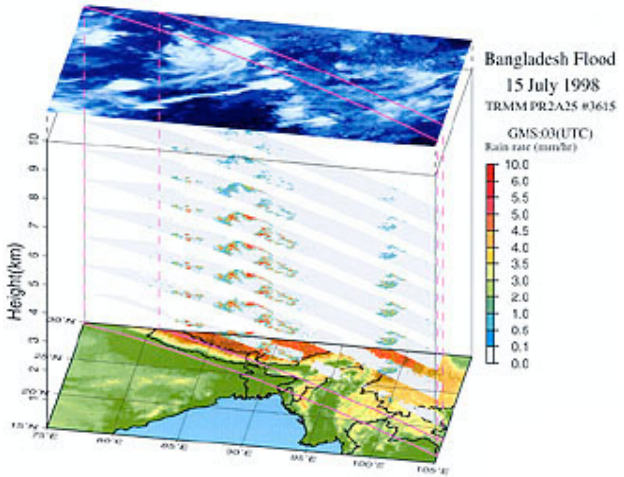


Fig. 1 3D Rainfall Distribution Observed by TRMM/PR on July 15, 1998 (orbit no. 3615) The top image shows GMS cloud data while the bottom image shows the topography and borders (see Fig.2 for a legend of colors used in the topography). Gray colored belts indicate TRMM/PR path in every 1 km height level. Blue, yellow, and red colors mean a degree of rainfall as shown an explanatory note. In the image of clouds, whiter color means higher altitude of cloud.

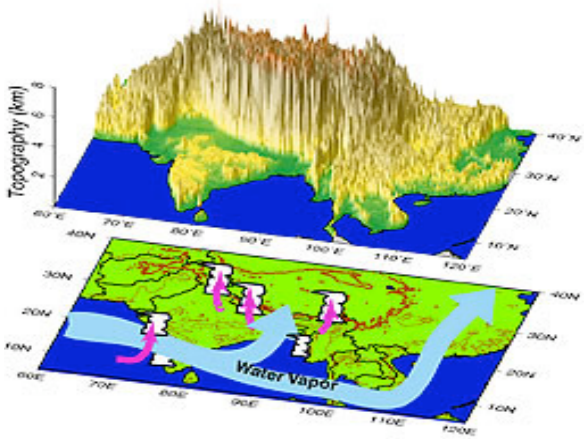
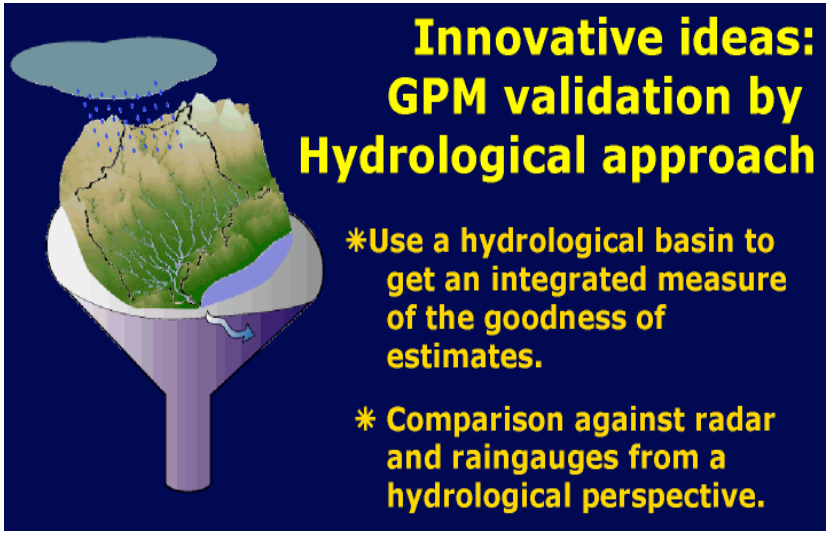


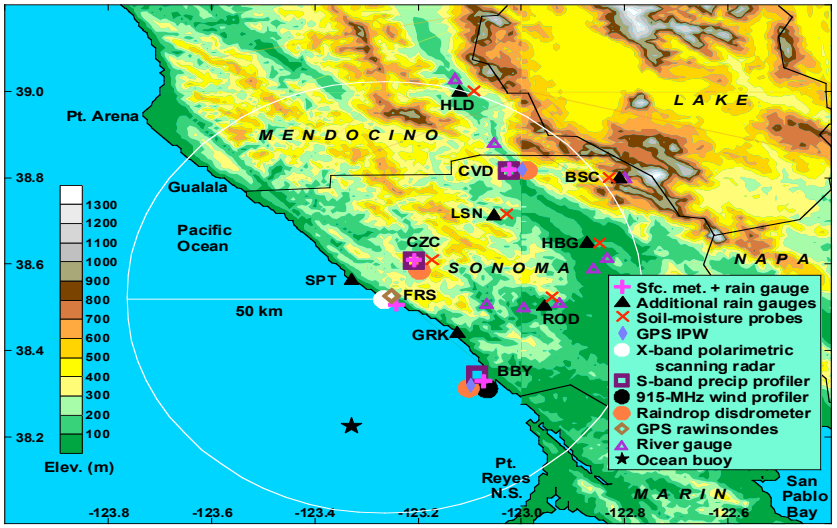
Fig. 2 Topography of South Asia
The lofty mountain mass corresponds to the Tibetan Plateau. The west-east mountain chain of this side is called the Himalayan Range. The bottom figure shows simulated paths of water vapor and it's upstream against the mountains during the monsoon season.

Integrated Hydrological Sites

- ***Goal: Establishing testbeds to improve usage of satellite precipitation data in hydrological applications.***
  - **augment existing watersheds or hydrological networks maintained by other US agencies (e.g. NOAA Hydrological Testbed Array, right) or international research programs with enhanced precipitation capabilities.**
- ***Possible instrumentation:***
  - **Profiler**
  - **Disdrometer or dense rain gauges for verifying the closure of the basin-scale water budget as derived from models and satellite**

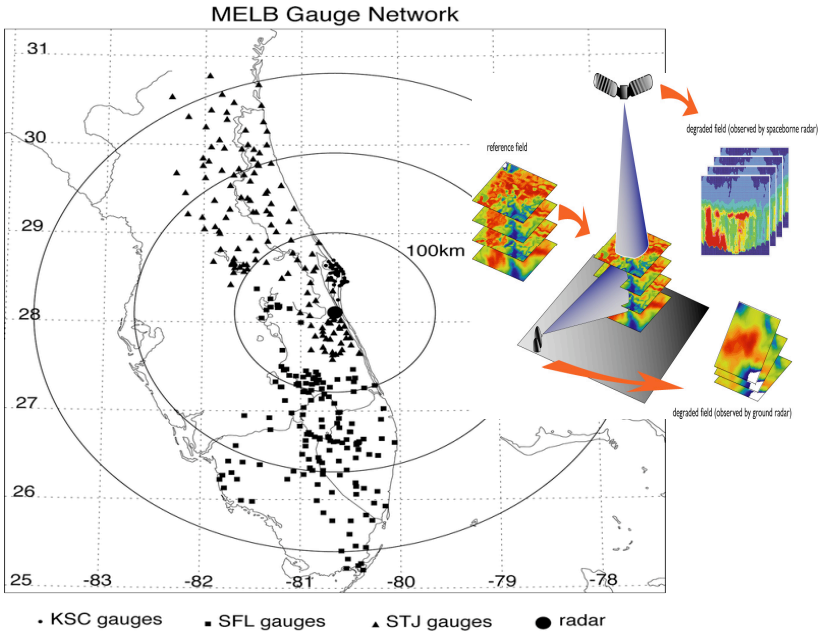


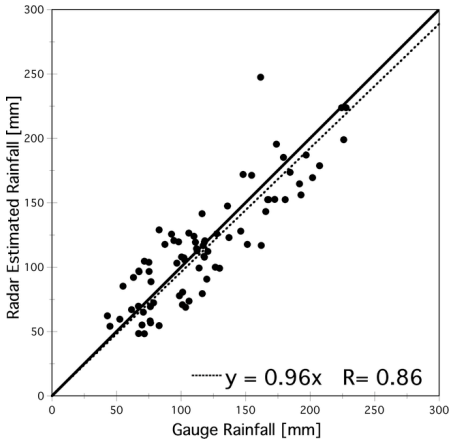
HMT-2004 Microphysics Array

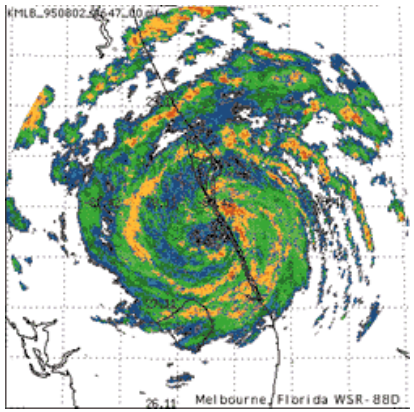


Precipitation Statistical Validation Sites

- ***Goal: Identifying and resolving significant discrepancies between the US national network and satellite estimates.***
- The national network is a carefully constructed composite of available national resources including radars and rain gauge networks, used primarily for comparison to identify systematic discrepancies in GPM products.
- Over oceans, the equivalent network is constructed using diverse satellite instruments. This is viewed as a research effort as no new observations are envisioned.
- Additionally:
  - Understand (and minimize) the errors associated with the geometry and timing of joint satellite and ground observations
  - Quantify the bias and errors contributed by individual ground and space-based instruments
  - Contribute to an error model of precipitation measurements







Role of Aircraft

- While not fully dedicated, aircraft measurements are crucial for verifying microphysical aspects of precipitation.
- The aircraft is a core component of the validation strategy and is designed to rapidly address issues in the precipitation retrievals that will undoubtedly surface as radar measurements are extended from the tropics into high latitude regimes.
- The aircraft should carry at the minimum the following instruments: Ku, Ka and W band radars (13, 35 and 95 GHz respectively), and microwave radiometers covering the spectrum from 10-340 GHz).

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: ED05–0149–1 Date: July 6, 2005 Photo By: Bill Ingalls

NASA's ER–2 takes off from the airport in San Jose, Costa Rica, to collect hurricane data during the Tropical Cloud Systems and Processes mission.

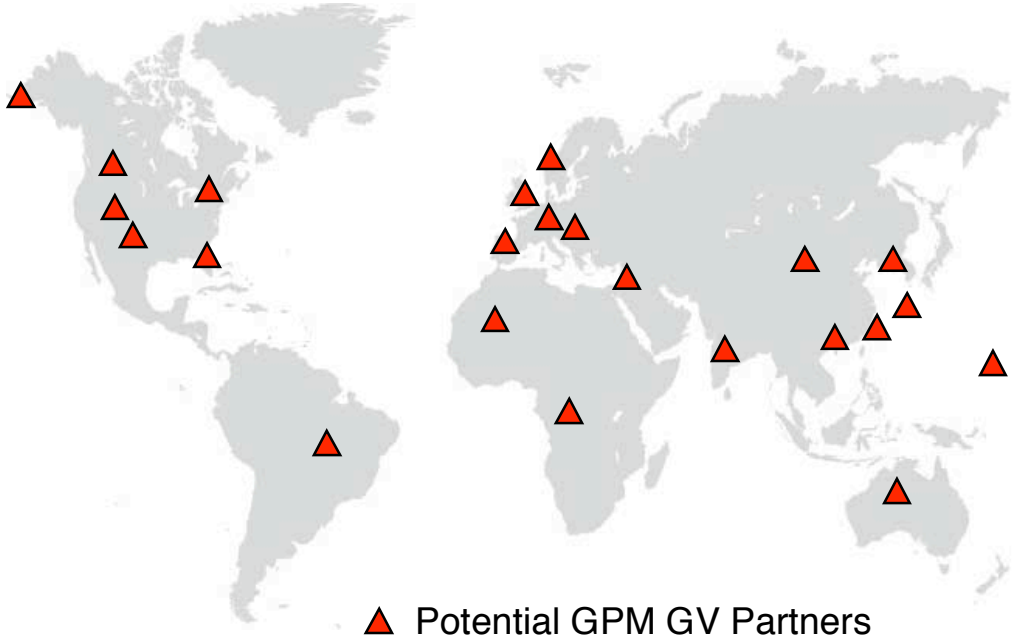
NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: EC04–0047–02 Date: February 24, 2004 Photo By: Jim Ross

NASA's Airborne Science DC–8, displaying new colors in a check flight Feb. 24, 2004, over the Dryden Flight Research Center.

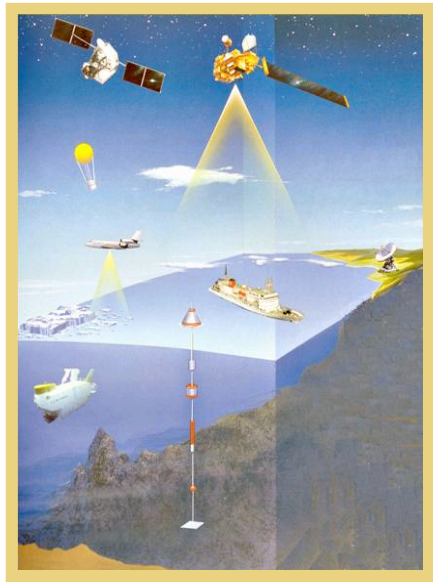
GPM GV Success Criteria

- ***Providing "microphysics laboratories" for improving satellite algorithms and GPM data products.***
- ***Providing stable, calibrated surface precipitation measurements as an independent assessment of satellite-based precipitation estimates.***
- ***Providing information for improving error characterization of satellite precipitation products for NWP and data assimilation applications.***
- ***Providing testbeds for improving satellite precipitation data usage in hydro-meteorological modeling and prediction.***

International Partnership: Key to GPM GV Success



▲ Potential GPM GV Partners



- *GPM was identified by United Nations in 2002 as outstanding example of Peaceful Uses of Space -- benefiting international scientific community and enabling important societal applications involving fresh water resources and environmental forecasting.*
- *GPM Mission's implementation approach is prototype for emerging Global Earth Observing System of Systems (1st Earth Observation Summit; Washington DC, 2003; Dept. of State).*